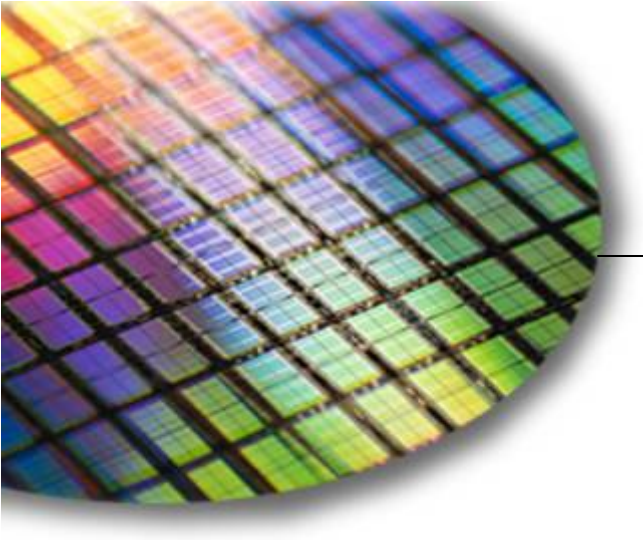

The World Leader in High Performance Signal Processing Solutions

Got My Data Across the Isolation Barrier, Now How Do I Get the Power There Too?

June 2013

ARROW
Five Years Out

ANALOG DEVICES

Introduction

- **And now that you have a working circuit, add isolation. This is much easier said than done, because isolation should be addressed at the initial design phase of any project.**
- **The challenges:**
  - **Determining the required level of isolation**
  - **Providing isolated power to complement the isolated data path**
  - **Making the solution fit the available space**
  - **Minimizing the design time**

Agenda

- Isolation 101
- Case Study – Powering Isolated RS485
  - Power supply options
  - DC/DC converter options
- *iso*Power® Technology – Integrated Chip Scale Power
- Conclusion
- More Information

When is Isolation Required?

- **The first question to ask when designing an isolated interface is;**
  - **Do I need to isolate this interface?**
- **Systems need isolation for many reasons**
  - **Safety – Is the barrier between people and dangerous (>60Vpeak) voltages**
  - **Functionality – Is this a high voltage level shifter, more robust interface**
  - **Noise Control – Does the isolation block electrical noise**
  - **Interoperability – Is isolation separating systems over long distances**
- **If your interface does not meet any of these criteria, then you may not need to isolate at all.**

Where to Begin?

- **The best time to plan for isolation is at the beginning of a project**
- **Become familiar with the IEC or UL safety standards that apply to your system.**
- **Choose your isolation scheme to provide the proper level of protection at each interface**
- **Minimize the signals that must cross the barrier**
- **Use serial connections like SPI or I^2C to keep the channel count low**
- **Take advantage of system resources like power supplies when they can easily be specified.**

Isolation 101

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Goals of a Safety Standard

- **Application of a safety standard is intended to reduce the risk of injury or damage due to the following**
  - **Electric shock**
  - **Energy related hazards**
  - **Fire**
  - **Heat related hazards**
  - **Mechanical hazards**
  - **Radiation**
  - **Chemical hazards**

Types of Standards

- **Most Common Systems Level Standards**
  - **Determine components specs based on system requirements**
    - IEC60664-1 (Insulation Coordination)
    - IEC 60950-1 (Information Systems)
    - IEC 60601-1 (Medical Equipment)
    - IEC 61010-1 (Instrumentation)
    - IEC61800-5 (Motor Drives and Inverters)
- **Piece Part Level Standards**
  - **Certify that components meet the manufacturers safety specifications, not certify to application requirements**
    - UL 1577 (Used for All Isolators)
    - IEC60747-5 (Optocoupler Isolators)
    - VDE 0884-10 (Non-optocoupler Isolators) – Reinforced only

Types of Isolation

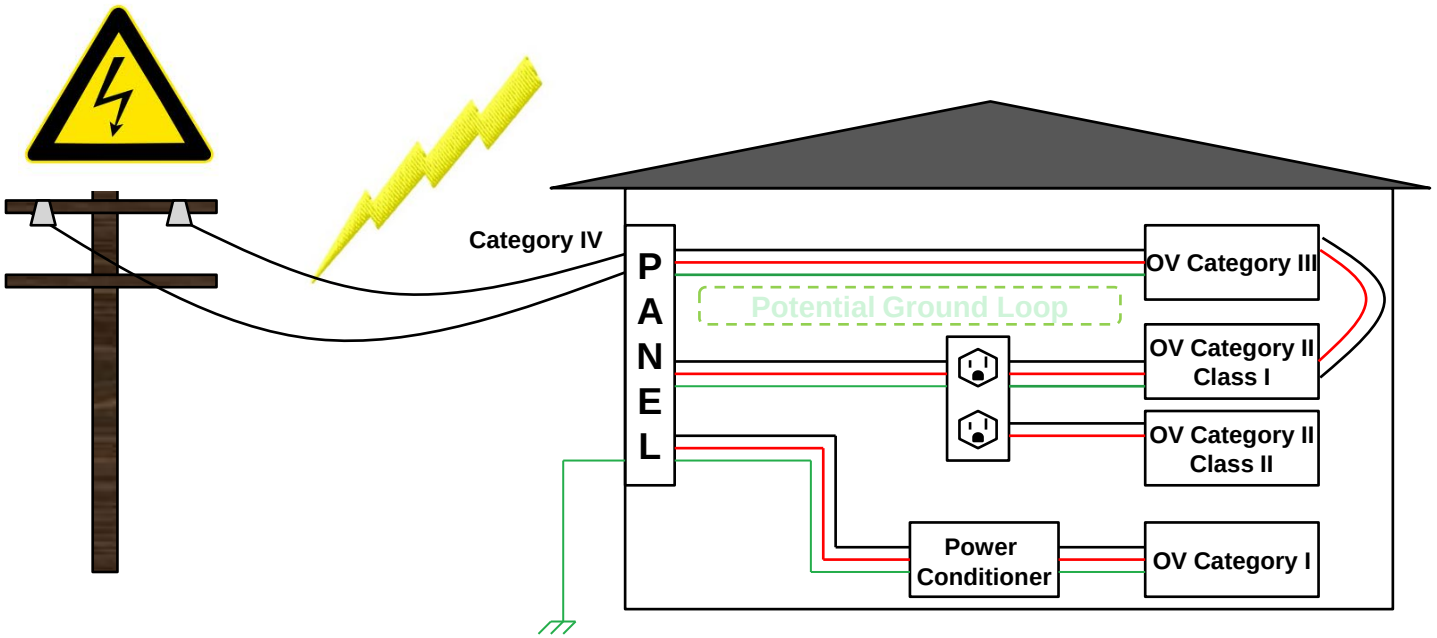
- **Functional Isolation**
  - **Circuit functionality only, not for protection**
  - **Elimination of ground loops and noise**
  - **Fault tolerance**

- **Safety Isolation protects people or other equipment from shock**
  - **Basic Insulation** – Protection from electric shock
  - **Supplemental Insulation** – Independent insulation in a system to protect from faults
  - **Double Insulation** – Both Basic and Supplemental applied together
  - **Reinforced Insulation** – A single insulation system demonstrated to be equivalent to Double Insulation

Elements of a Safe System

- **Accessible parts must be protected from:**
  - **Mains voltage**
  - **Transients on the Mains**
  - **Hazardous secondary voltages**
  - **Internally generated transients**
- **Basic Insulation includes:**
  - **Galvanic isolation**
  - **Earth referenced secondary circuits containing**
    - Overvoltage protection
    - Current limiting
- **Double Insulation or Reinforced Insulation is required to the Mains or dangerous secondary voltages**
- **Voltages under fault conditions must be limited**

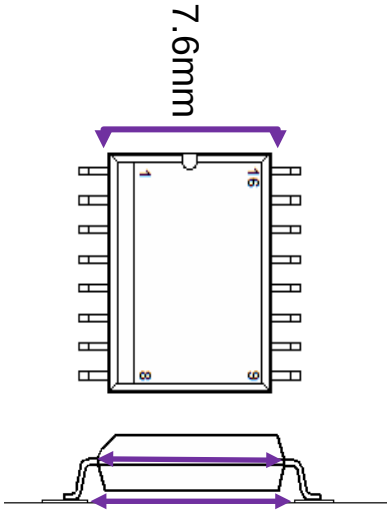
Classifying the Application

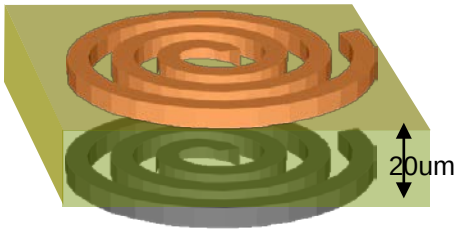


- **Over Voltage Categories**
  - Category IV – Direct to Grid
  - Category III – Fixed Instillation
  - Category II – Temporary Connection
  - Category I – Protected Installation
- **Equipment Class**
  - Class I – Protective Earth
  - Class II – No Protective Earth

Parameters that characterize isolation

- **Insulation grade**
  - Basic
  - Supplementary
  - Reinforced
- **Working Voltage across a barrier**
  - Distance along surface to protect from tracking (creepage)
  - Insulation lifetime
- **Transient Voltage**
  - Distance through air that would prevent arcing (clearance)
  - Distance through Insulation (internal clearance)
  - Distance along material boundaries
  - Breakdown threshold of the insulation
- **Environment of the application**
  - Type of contamination at the isolation barrier
  - Air pressure range (altitude of operation)





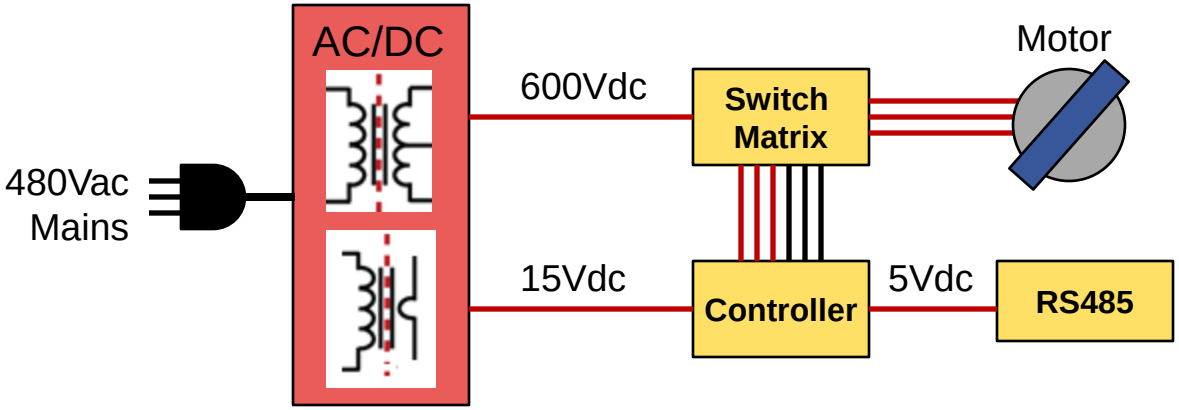
Polyimide Isolation

What does it mean?

- **There must be two layers of protection between a person and a dangerous voltage**
  - **Basic + Supplemental**
  - **Reinforced**
  - **Basic + Earth Referenced Ground**
- **Values of creepage and clearance depend on**
  - **Working voltages across barriers**
  - **Transient voltage across barriers**
  - **Insulation materials**
  - **Proximity to the building mains**
  - **Environment, including pollution, operating altitude**
- **Working voltage categories**
  - **Hazardous Voltage - >60Vdc or 48Vac**
  - **ELV – Extra Low Voltage - <60Vdc or 48Vac high power available**
  - **SELV – Safety Extra Low Voltage**

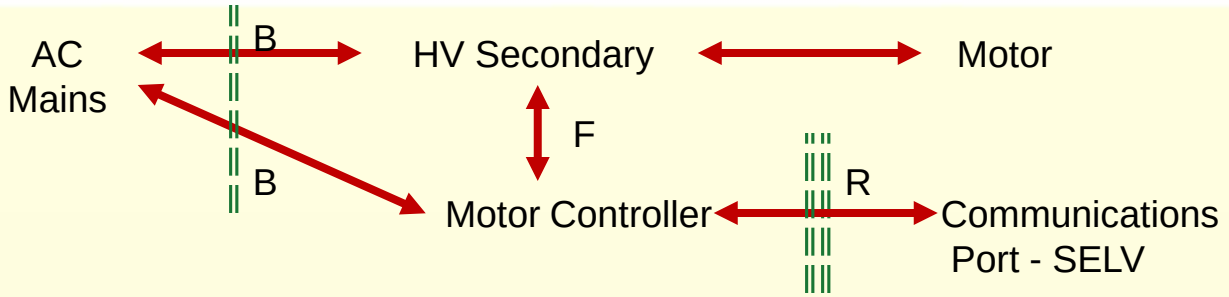
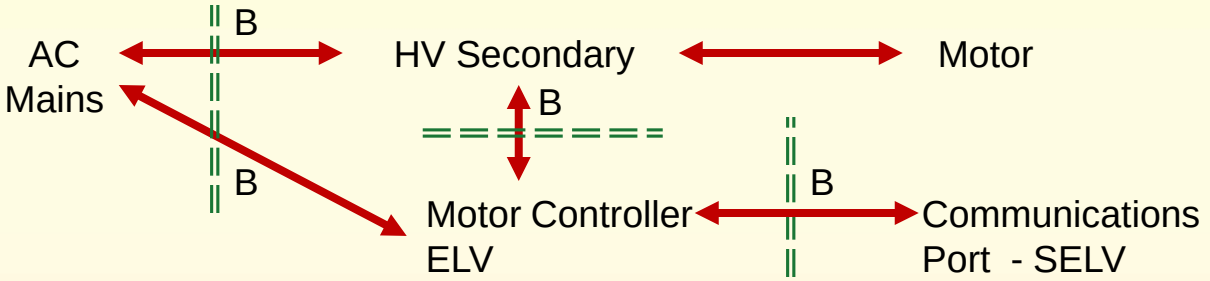
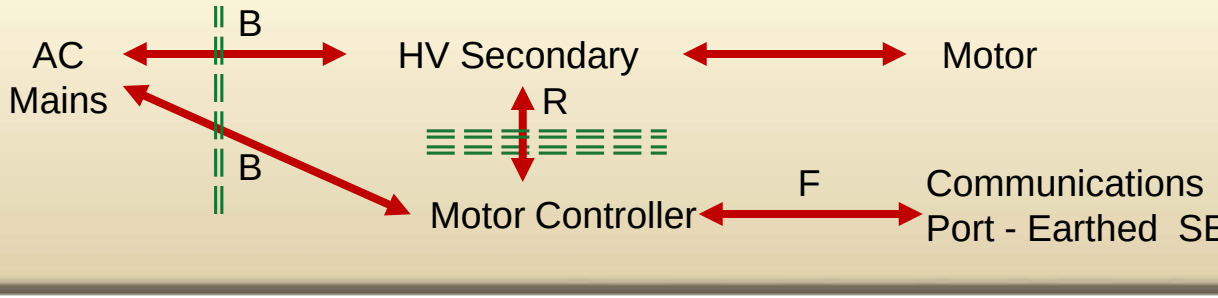
Power Supply Options

System Example – Motor Controller



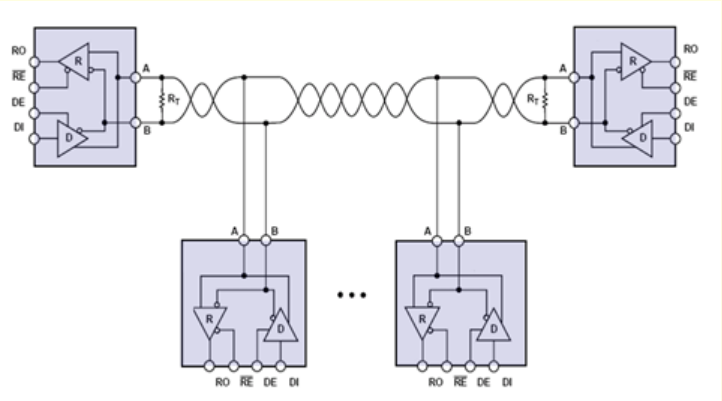
- **Motor drive illustrates several power and data interfaces**
  - **480V mains interfaces with both Hazardous Voltage Bus, and controller power**
  - **Controller must interface with Hazardous Voltage Bus switches**
  - **Controller must interface with communications**
- **Deciding which interfaces provide safety determines the required isolation**

System Partitioning

Using Functional isolation for the gate drivers pushes reinforced insulation for communications	
Using Basic isolation for the gate drivers allows Basic insulation for communications	
Using reinforced isolation for the gate drivers can eliminate the need for galvanic isolation	

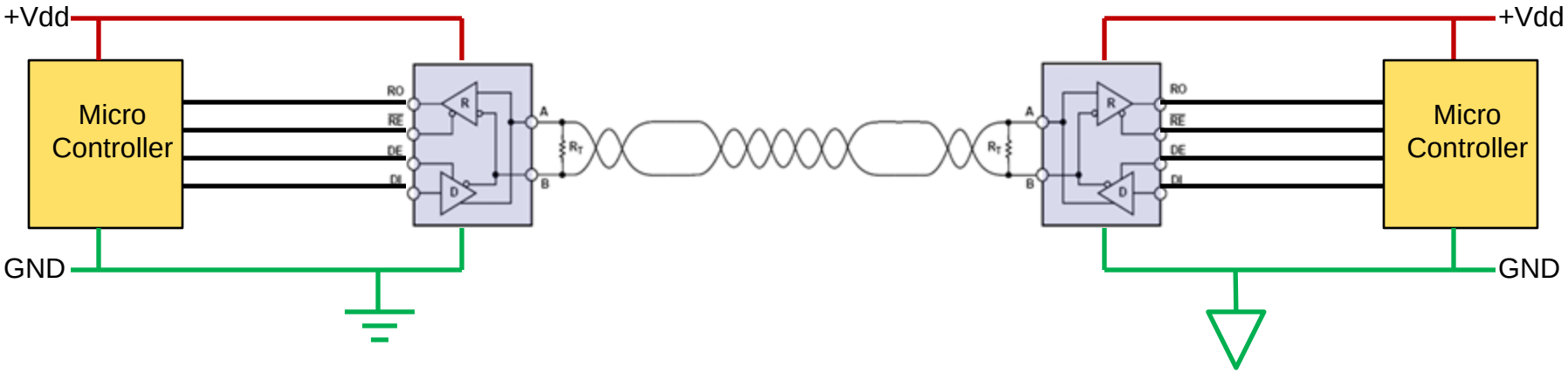
Multi-Drop RS485 Case Study

- **The communications interface provides a good case study**
  - Each node can have a different isolation requirement
  - Isolation can be determined by design choices
  - Each node with isolation requires both data and power on each side of the barrier



- **Design Goals**
  - Data interface performance
  - High level of integration minimizing board space
  - Isolated power
  - Ease of design
  - Reliability – meeting the standard's requirements

Non-Isolated Implementation



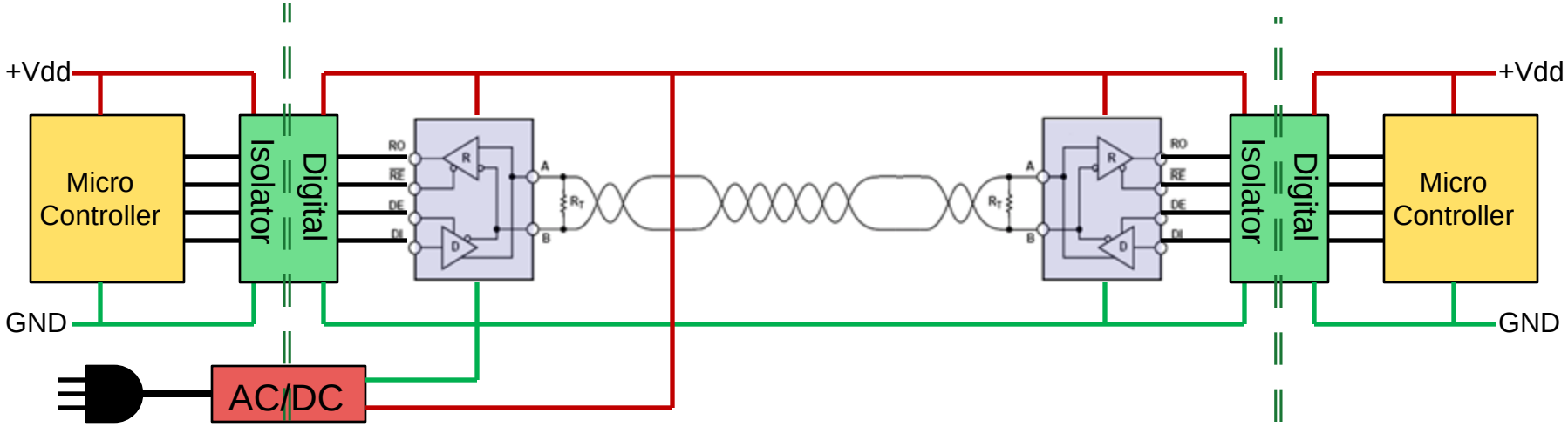
Advantages

- Power can be provided through the controller supplies

Disadvantages

- Operation depends on common mode range of the transceivers
- Cable shielding is vulnerable to ground loop injected Noise
- No transient rejection of any kind
- Increases the cost of isolation in other parts of the application

Isolated Bus Powered Implementation



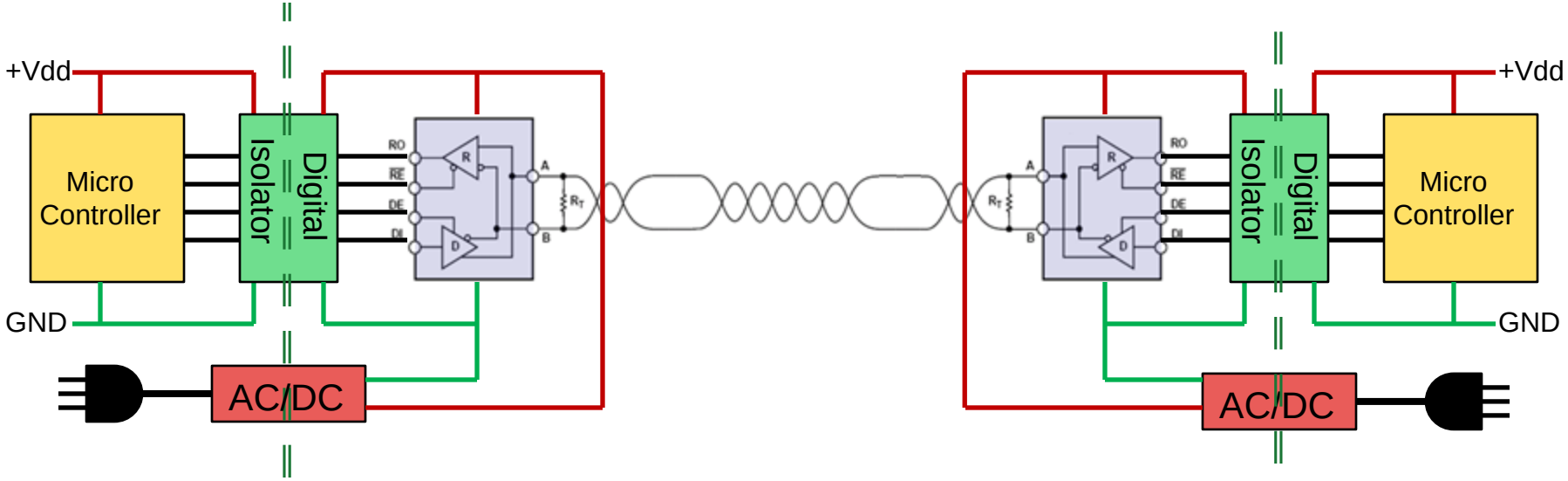
Advantages

- One power supply powers the entire isolated bus
- Supplies off the self with proper safety rating
- Only digital data goes across the isolation barrier
- DC/DC can pull power from the bus

Disadvantages

- Added cabling costs
- No redundancy in the supply, all nodes go down if power is lost
- Requires a Standard to regulate power like Device Net

Isolated Bus Dedicated Transformer Winding



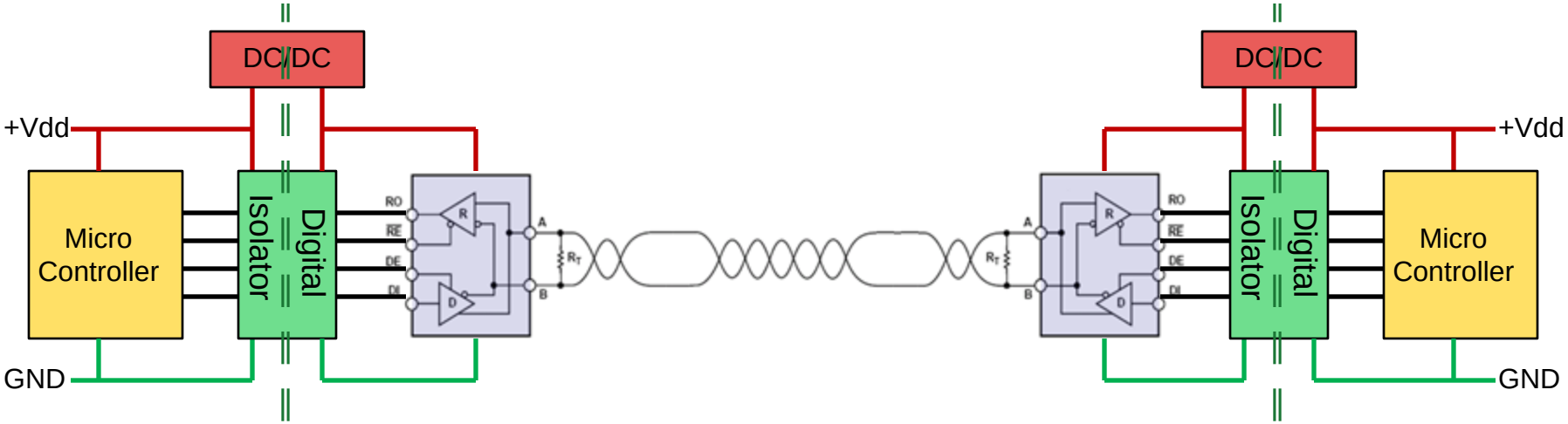
Advantages

- Power provided from the local off line supply
- Each node operates independently

Disadvantages

- Must have control of the off line power supply design
- Must be close to the off line supply, not practical in rack systems

Isolated Converter Supplied Power



Advantages

- Modular solution available
- Power is transferred from the local ELV supply
- Power is redundant for each node
- No direct interaction with the off line supply

Disadvantages

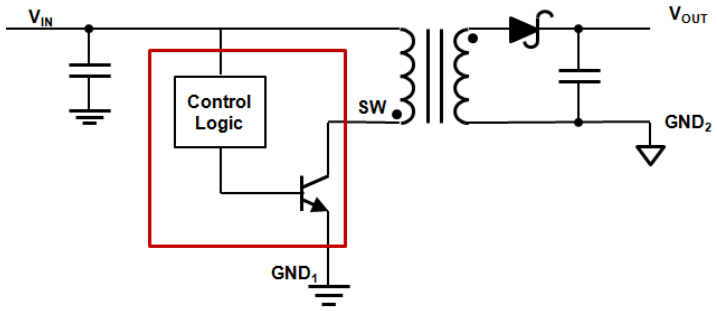
- Home made converters are another design effort
- The converter must meet the isolation requirement of the interface
- Hard to find reinforced modules
- Modules can be large

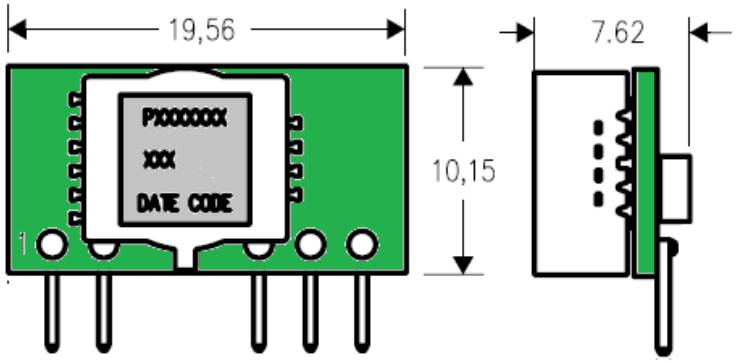
DC/DC Converter Options

ANALOG DEVICES

Unregulated Power

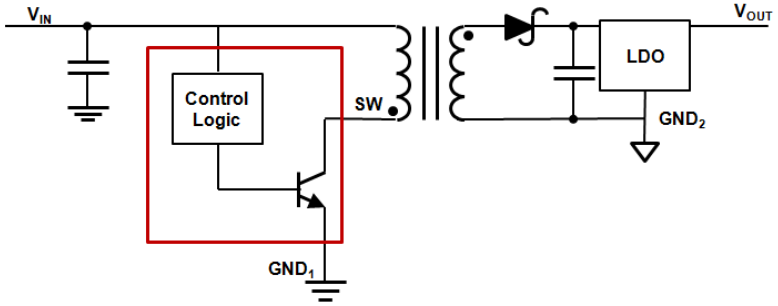
- **Very simple solution**
  - Fixed frequency
  - Fixed duty cycle
  - Optimized for max load
  - Discrete transformer
- **It can shift expense onto other components**
  - Poor line and load regulation
  - Unstable operation at very light loads
  - Large footprint and or height
- **The design must tolerate sloppy or unstable power**

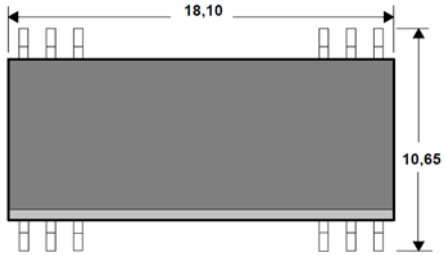




Secondary Side Linear Regulation

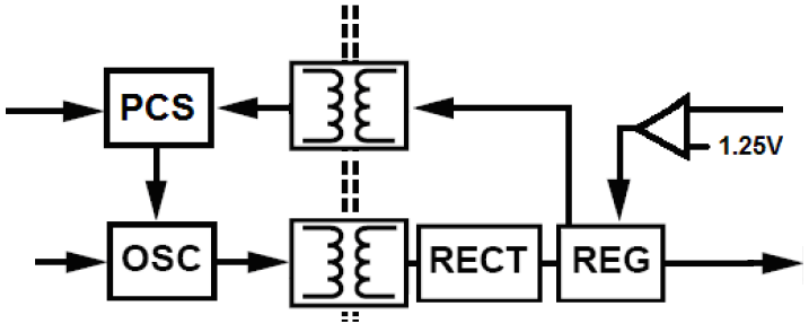
- **Next step up in complexity**
  - Good regulation
  - Integrated wire wound transformer
  - Fixed frequency
  - Fixed duty cycle
  - Optimized for max load
- **Still not optimum**
  - Large footprint
  - Wastes power at light loads

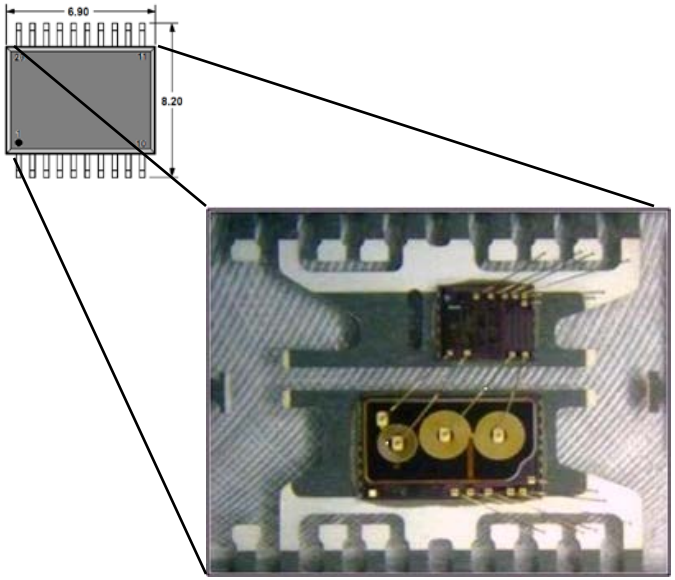




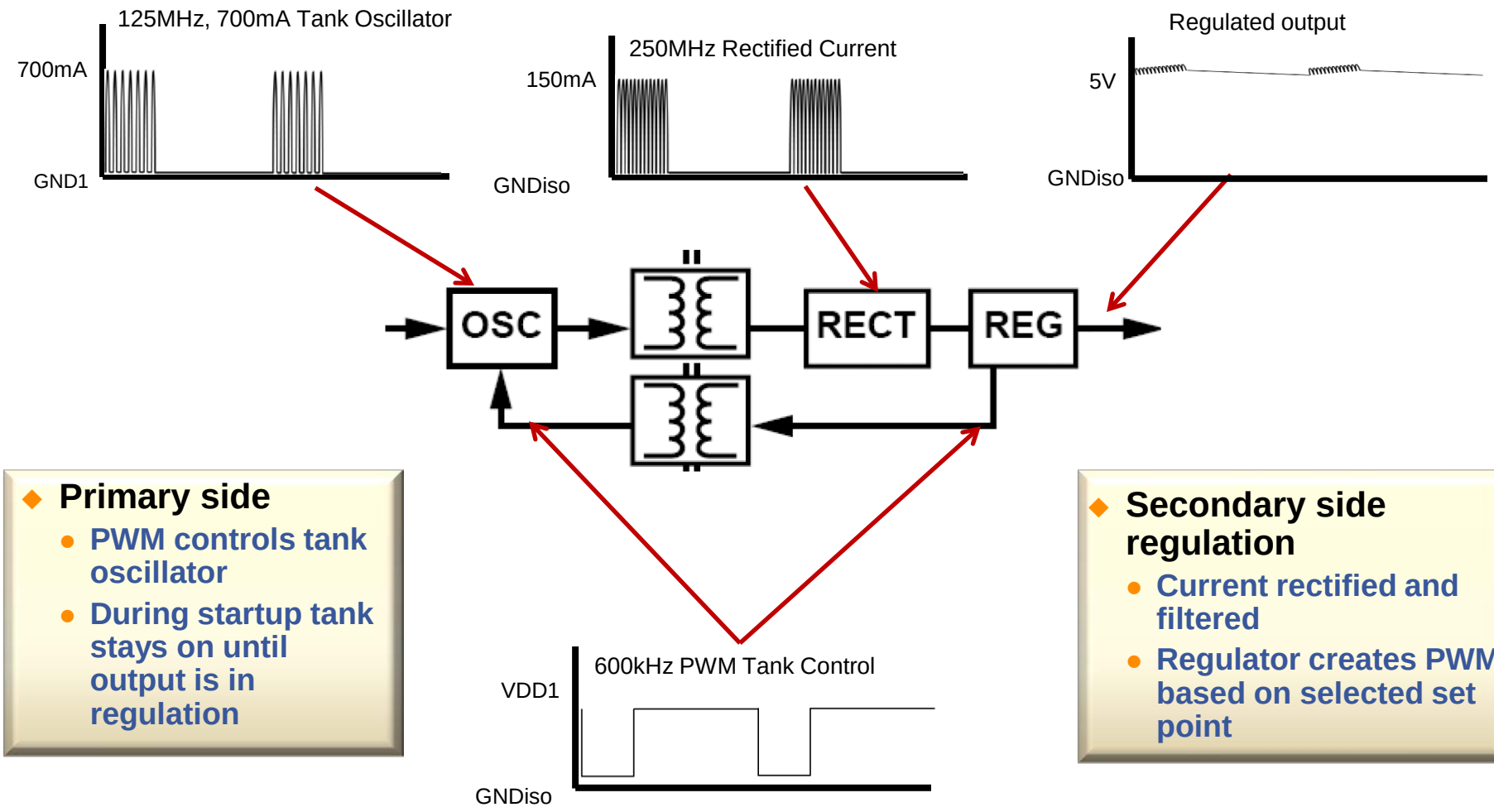
Chip Scale Power Module

- **Highly integrated**
  - Fixed frequency
  - Variable duty factor
  - Constant efficiency over entire load range
  - Excellent line and load regulation over the entire load range
  - Chip scale transformer
  - Features of brick power supply
  - Very small solution size
- **It can shift expense onto other components**
  - Must design for EMI





How Chip Scale Converters Work



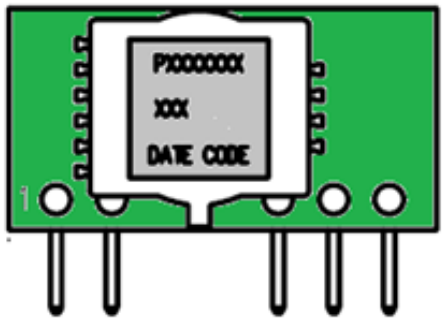
- **Primary side**
  - PWM controls tank oscillator
  - During startup tank stays on until output is in regulation

- **Secondary side regulation**
  - Current rectified and filtered
  - Regulator creates PWM based on selected set point

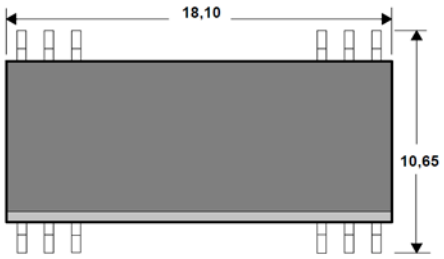
Comparison of Power Options

Type	P/N	Peak Effcy.	Quiescent Current	Max Power	Load Reg.	Size	Cost (1K)
Chip Scale Converter	ADuM5000	33%	6mA	500mW	1.3%	10x10x2	$3.16
Regulated Module	DCR010505	50%	18mA	1W	3%	18x10x2.5	$5.95
Unregulated Module	DCH010505	72%	60mA	1W	10%	20x8x10	$4.25

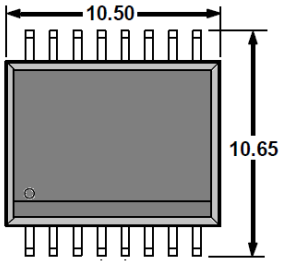
Unregulated Module



Regulated Module

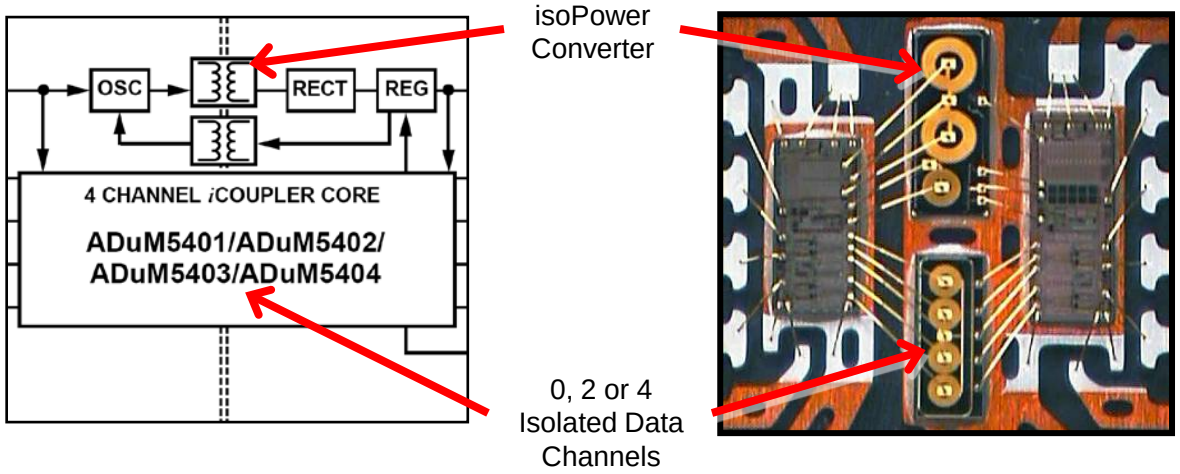


Chip Scale Converter



ADI *iso*Power and *i*Coupler® Devices

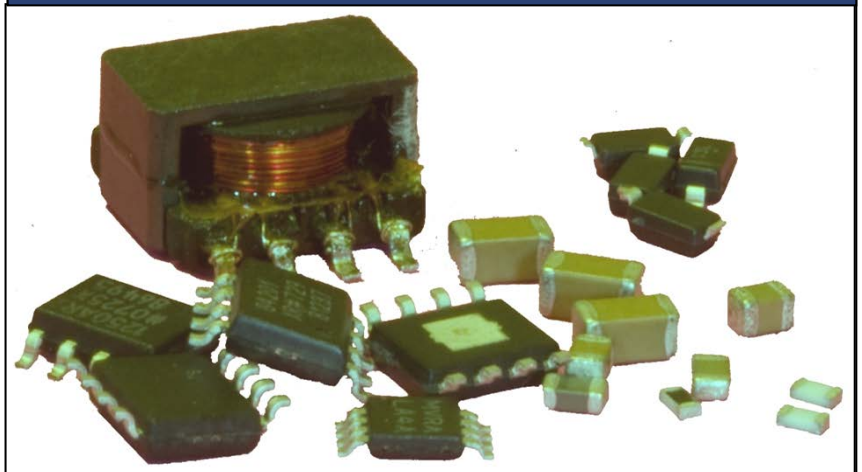
*iso*Power Integration



- ***iso*Power and *i*Coupler use the same basic technology**
  - **Reinforced or Basic insulation up to 5kV withstand**
  - **Data channels are easily combined with power**
  - **Other functions like transceivers, USB or I^2C can be added as well**

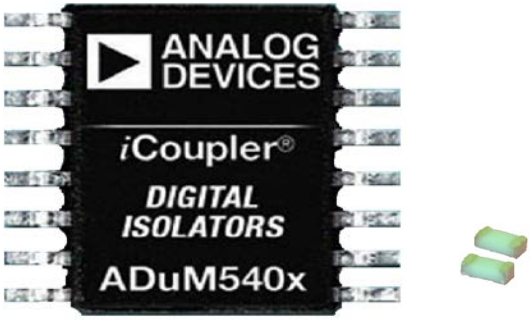
*iso*Power Single Package Solutions

Discrete DC/DC & Optocoupler Based Solution



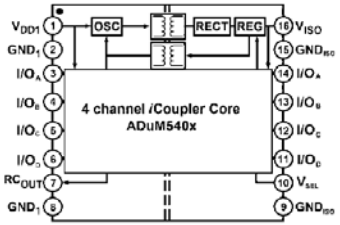
4 Digital Optocouplers
Transformer
Transformer Driver
Linear Regulator
4 Rectifying Diodes
Input / Output Caps
4 Resistors
3 Capacitors

One Package *iso*Power Solution

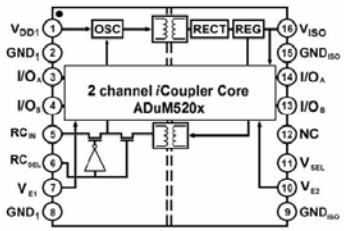


ADuM540x – Basic Isolation
Or
ADuM640x – Reinforced Isolation
&
4 Bypass Capacitors

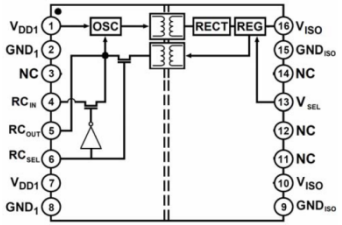
Characteristics of *iso*Power



ADuM540x 4 channel



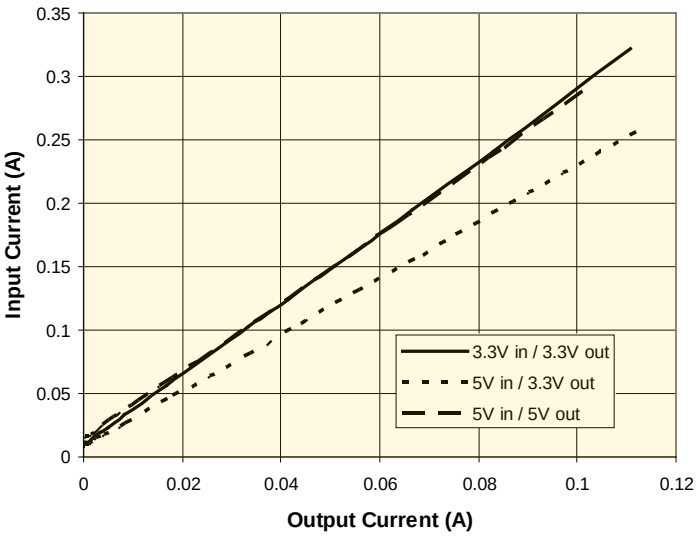
ADuM520x 2 channel



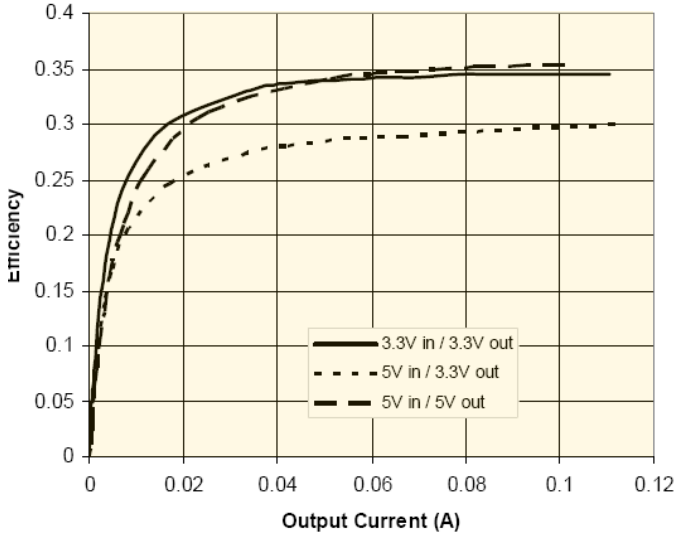
ADuM5000 Supply Only

- **Low quiescent current**
- **Good characteristics at light loads**
- **Flat Efficiency Curve**

Input Current vs. Load

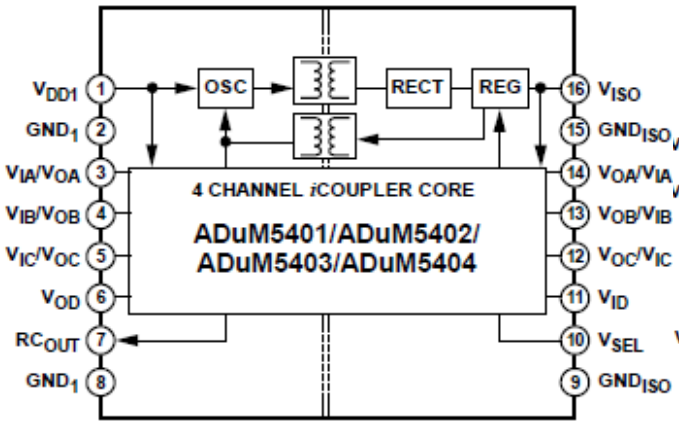


Efficiency vs. Load

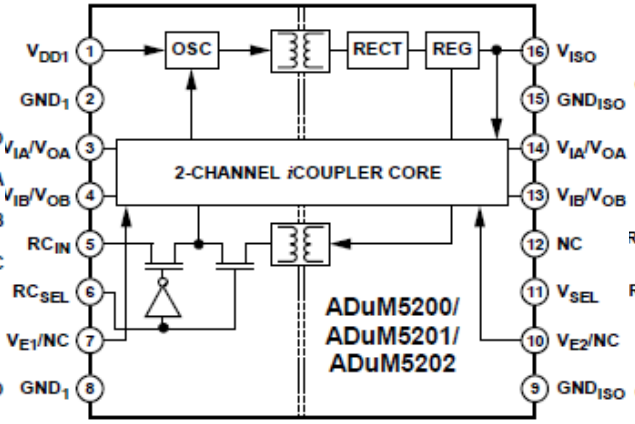


½W *iso*Power Products

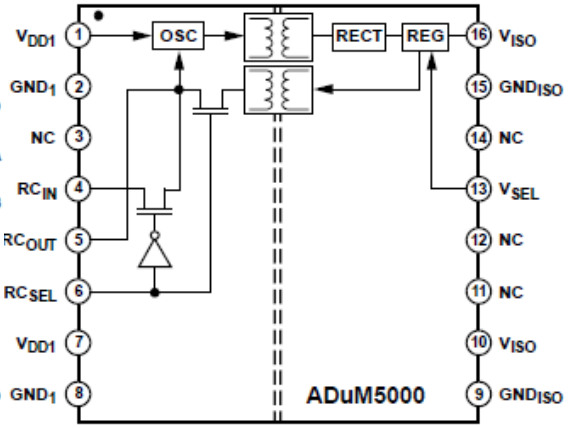
ADuM540x
ADuM640x



ADuM520x
ADuM620x



ADuM5000
ADuM6000

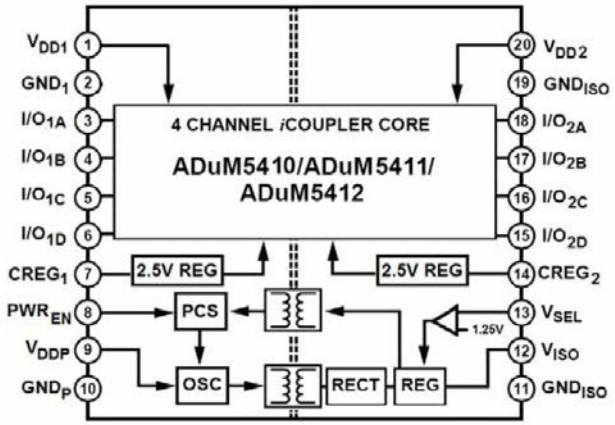


Key Features

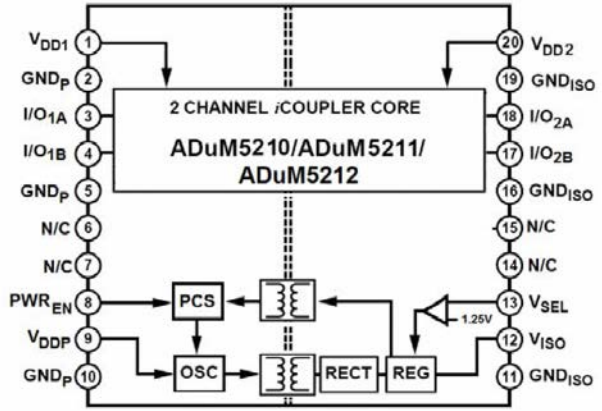
- Selectable, Regulated V_{ISO}: 3.3V or 5 V
- 500mW @ 3.3 or 5V output
- SO16W or SO16WRI extended creepage Package
- 0, 2, and 4 *i*Coupler signal channels – Up to 25 Mbps
- IEC60601 medical certification
- Reinforced insulation up to 5kV rms

Reduced Cost & Size *iso*Power Products

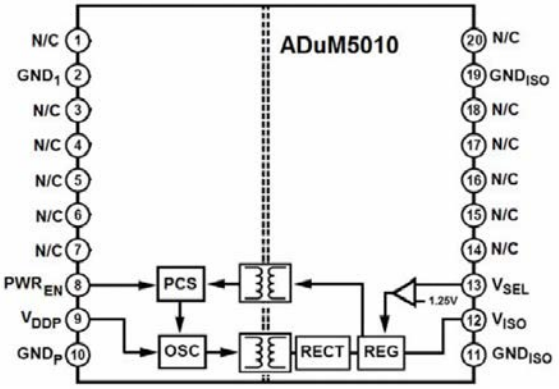
ADuM541x
ADuM641x



ADuM521x
ADuM621x



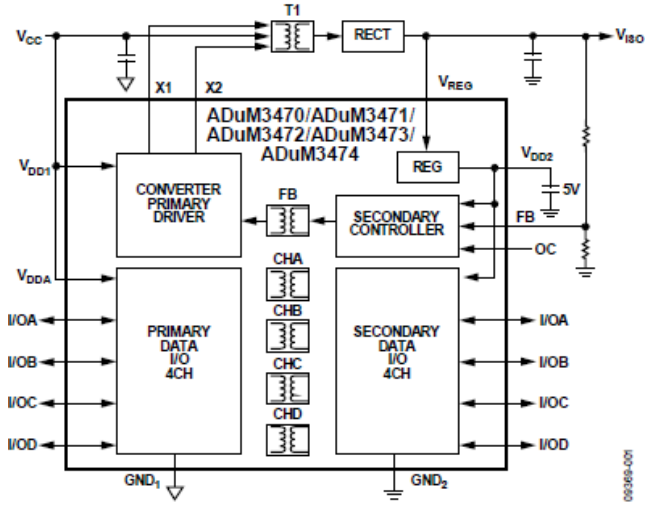
ADuM5010
ADuM6010



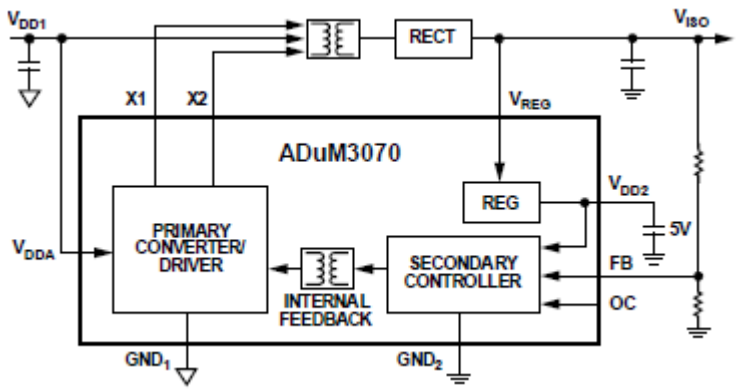
- **Key Features**
  - Adjustable, Regulated V_{ISO}: 3.15V to 5.25V
  - 150mW @ 3.3 or 5V output
  - Soft-start Power Supply
  - Small SSOP Package
  - 0, 2, and 4 *i*Coupler signal channels – Up to 150 Mbps
  - Reinforced insulation up to 3.75 kV rms

Isolated Switching Regulators

ADuM347x
ADuM447x

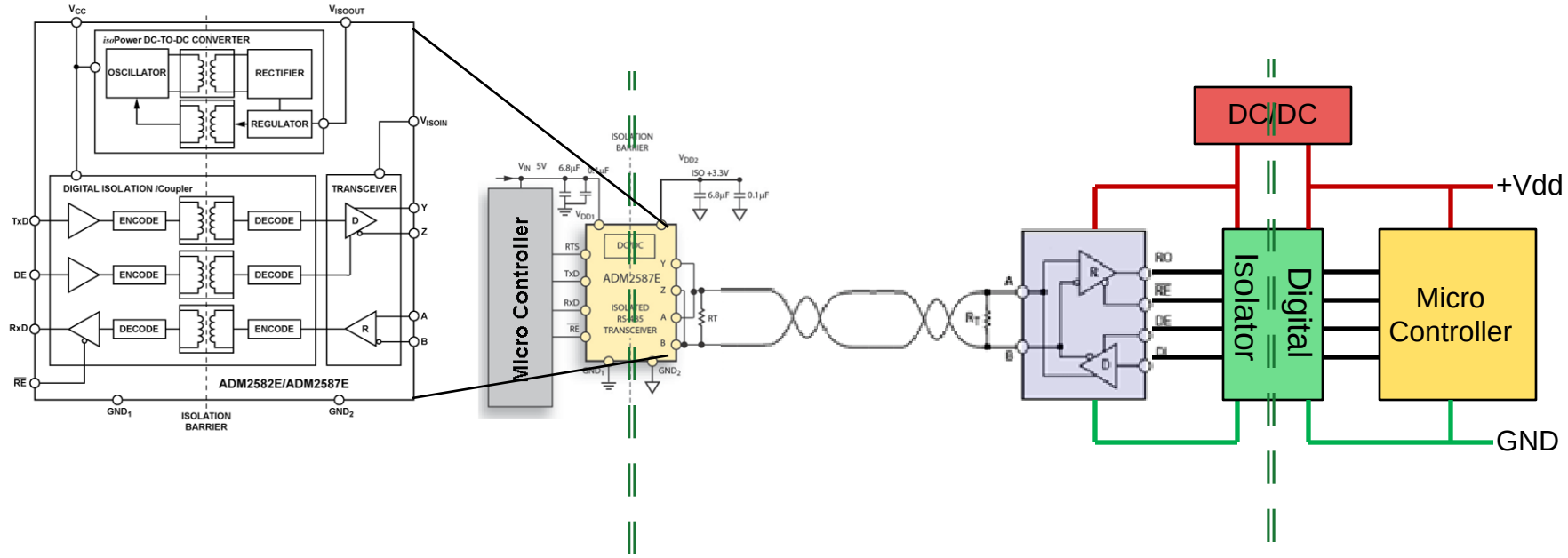


ADuM3070
ADuM4070



- **Key Features**
  - Adjustable, regulated V_{ISO}: 3.3 to 30V
  - Up to 2.5W output power
  - Soft-start power supply
  - Pulse by pulse current limiting
  - Low emissions
  - 70% efficient
  - 0 or 4 *i*Coupler signal channels – Up to 25 Mbps
  - Reinforced insulation up to 5kV rms
  - SSOP20 and SO16WRI packages

Even Higher Levels of Integration



- ***iso*Power and *i*Coupler are integrated with high speed transceivers, ADM2587E**
  - **Basic insulation up to 2.5kV withstand**
  - **Up to 16Mbps**

Summary

- **Meeting regulatory requirements for an isolated system can be approached from two paths:**
  - **System Architecture Choices**
  - **Component level solutions**
- **The design bottle neck has become power isolation**
- **Devices are now available that integrate:**
  - **Isolated power**
  - **Isolated data**
  - **Interface specific front ends**
- ***i*Coupler/*iso*Power technologies address complex isolation issues at the IC level**

Products Discussed in This Webcast

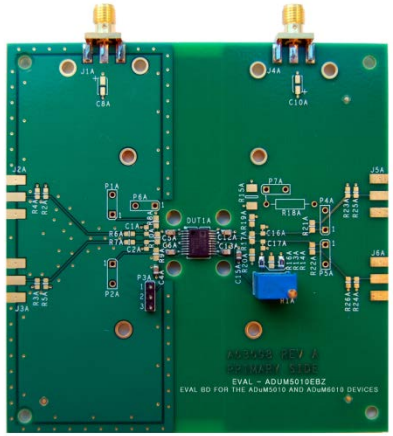
ADuM5000	2.5 kV rms Isolated DC/DC Converter with Up to 500 mW Output Power	www.analog.com/ADuM5000
ADuM6000	5 kV rms Isolated DC/DC Converter with Up to 400 mW Output Power	www.analog.com/ADuM6000
ADuM5010	2.5 kV rms Isolated DC/DC Converter with Up to 150 mW Output Power	www.analog.com/ADuM5010
ADuM6010	3.75 kV rms Isolated DC/DC Converter with Up to 150 mW Output Power	www.analog.com/ADuM6010
ADuM520x	2.5 kV rms Dual-Channel Isolators with Integrated DC/DC Converter w ith Up to 500 mW Output Power	www.analog.com/ADuM520x
ADuM620x	5 kV rms Dual-Channel Isolators with Integrated DC/DC Converter with Up to 400 mW Output Power	www.analog.com/ADuM620x
ADuM521x	2.5 kV rms Dual-Channel Isolators with Integrated DC/DC Converter with Up to 150 mW Output Power	www.analog.com/ADuM521x
ADuM621x	3.75 kV rms Dual-Channel Isolators with Integrated DC/DC Converter with Up to 150 mW Output Power	www.analog.com/ADuM621x
ADuM540x	2.5 kV rms Quad-Channel Isolators with Integrated DC/DC Converter with Up to 500 mW Output Power	www.analog.com/ADuM540x
ADuM640x	5 kV rms Quad-Channel Isolators with Integrated DC/DC Converter with Up to 400 mW Output Power	www.analog.com/ADuM640x
ADuM541x	2.5 kV rms Quad-Channel Isolators with Integrated DC/DC Converter with Up to 150 mW Output Power	Coming Soon
ADuM641x	3.75 kV rms Quad-Channel Isolators with Integrated DC/DC Converter with Up to 150 mW Output Power	Coming Soon
ADuM3070	2.5 kV rms Isolated Switching Regulator	www.analog.com/ADuM3070
ADuM4070	5 kV rms Isolated Switching Regulator	www.analog.com/ADuM4070
ADuM347x	2.5 kV rms Quad-Channel Isolators with Integrated Switching Regulator	www.analog.com/ADuM347x
ADuM447x	5 kV rms Quad-Channel Isolators with Integrated Switching Regulator	www.analog.com/ADuM447x
ADM2587E	Signal and Power Isolated RS-485 Transceiver with ± 15 kV ESD Protection	www.analog.com/ADM2587E

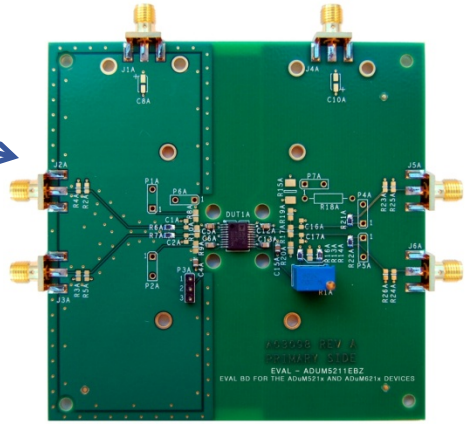
Want Additional *iso*Power Information?

Visit www.analog.com/*iso*Power

Resources Available on the Web Include:

- **Webcast and Videos**
- **Application Notes**
- **Technical Articles**
- **Regulatory Agency Certifications**
- **Datasheets**
- **Evaluation Boards**
  - **EVAL-ADuM5010EBZ**
    - Supports the ADuM5010/ADuM6010
  - **EVAL-ADuM5211EBZ**
    - Supports the ADuM521x/621x families
  - **EVAL-ADuMQSEBZ**
    - Supports the ADuM5000, ADuM6000, ADuM520x, ADuM620x, ADuM540x and ADuM640x families.





New *iso*Power Technical Article Available

ANALOG DEVICES

Technical Article
MS-2411

Optimizing Power Conversion for Isolated Sensor Interfaces

by Mark Cantrell, Applications Engineer, Analog Devices, Inc.

IDEA IN BRIEF

In the world of industrial controls, only a few things are certain; the next product will have a smaller form factor, more channels, and have a lower target cost per channel. The expectation is that technology has improved since the last design and all of these things are possible. To a large extent, that is the way things have worked out in the past, and your luck may be holding.

The data interfaces have been improving steadily from the era of optocouplers to the latest high speed low power highly compact digital isolators. In this article, we will examine one aspect of isolated sensor interfaces that gets less attention than it deserves. How do we get isolated power to the ADC and conditioning circuits while shrinking the size of the interface and improving performance? In the past, the analog interface boards did not have high channel counts, so there was enough room on the board for a modest dc-to-dc converter to be designed to provide power to the sensor interface. Power dissipation was not a great concern since there were only one or two interfaces to a module. Currently, analog PLC modules, as illustrated in Figure 1, can have four, eight, or even 16 independent isolated channels. Multiple copies of a modest dc-to-dc converter take up a lot of space and create a lot of heat.

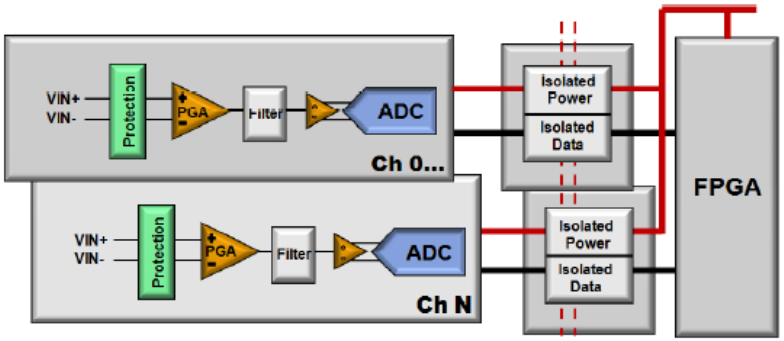


Figure 1. Typical Multichannel Sensor Interface

www.analog.com/ms-2411

For More Information on the *i*Coupler Digital Isolator Portfolio

Visit www.analog.com/*i*Coupler

Resources Available on the Web Include:

- Webcast and Training Videos
  - www.analog.com/digitalisolatorvideos
- Circuits from the Lab™
- Application Notes
- Technical Articles
- Safety Standards/Certifications

Key Application Notes:

- AN-825 Power Supply Considerations in *i*Coupler Products
- AN-1109 Control of Radiated Emissions with *i*Coupler Devices
- AN-793 ESD/Latch-up Considerations with *i*Coupler Products

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